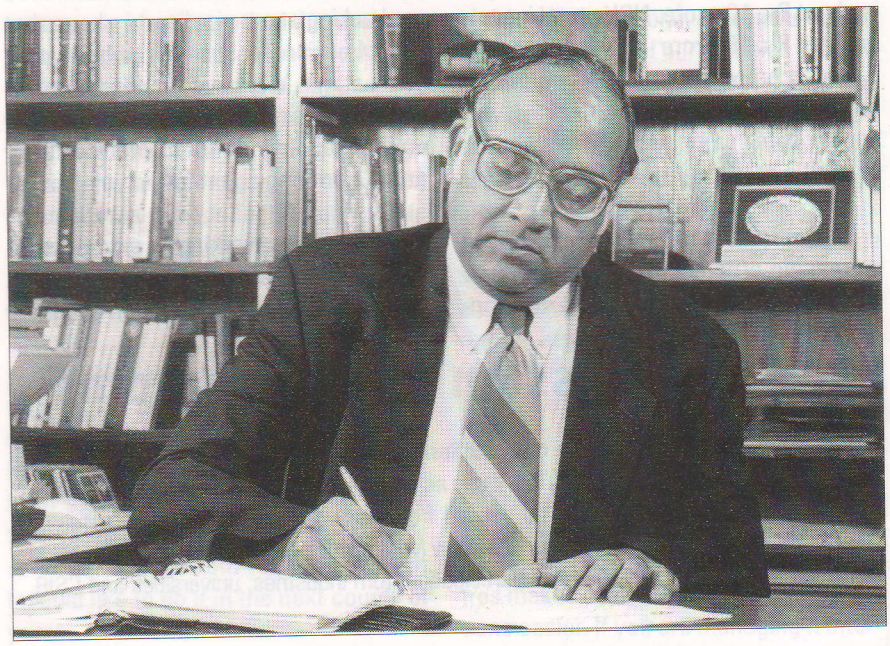
CHEMICALS RESEARCH

National Chemical Laboratory leads Indian charge in global chemical research league

National Chemical Laboratory, Pune, a front ranking institution devoted to chemical research has been pushing new frontiers ever since Dr. Swaminathan Sivaram, India's leading polymer scientist, took charge as Director three years back. It has shifted gears and redefined several aspects of the business processes associated with chemical R&D to emerge as a force to reckon with globally.



Discussing why basic science is key to future growth, Dr. Sivaram says, "Our core strength in basic research has sustained the laboratory over the past 50-years and will continue to do in the future. For me that is the fountainhead of everything that we do. The main reason why we are able to attract the best talent to the lab and are able to keep pace with the developments around the world is basically because the lab has and continues to sustain a very high quality of science".

NCL, which had around 240 research fellows in 2002, now has 400+ research fellows who are driving the basic sciences. From 340 papers published in 2002, NCL published a total of 440 papers in leading scientific journals of the world in 2004, with an average impact factor (IF) of 2.13. In comparison, Indian Institute of Science, Bangalore has an IF of around 2.5 for all its published papers. Dr. Sivaram attributes this increase to a large community of high quality research fellows.

NCL accounts for nearly 16% of the scientific publications of all labs under the Council for Scientific and Industrial Research (CSIR), yet has only 6.5% of the scientific manpower of CSIR. "It has been quality, as well as quantity", says Dr. Sivaram and adds that many NCL papers are well cited and frequently featured on the covers of many international journals.

NCL today boasts of seven scientists who are recipients of the prestigious Bhatnagar awards and several Fellows of learned academies of science and engineering in India. As regards patents, NCL continues to be a leader. Last year, it was granted 35 Indian patents and 30 patents abroad. These are basically related to catalysis, fine chemicals and polymers. In fact the laboratory has a share of 20% of all patents granted to CSIR.

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In this exclusive interview to *Chemical Weekly,* Dr. Sivaram lays out his vision and strategies to propel NCL into a new future. Excerpts:

What are your views on innovation in research practices? To what extent are these at play in your research management?

One of the important aspects I looked at after I took over as Director was to bring our strengths across various knowledge disciplines to focus on what I

call the 'directed mission mode' research. The aim was to look at few programmes in the lab where I could get a wide variety of skills to converge and get them to work together with a unity of purpose.

I believe that really large problems are amenable to solutions only in this manner. Within the narrow confines of a group or a division or a research entity, you can handle only a limited number of challenges. My goal was to drive the culture and behaviour because, I believe, this Lab must learn to work as a team, if it has to ascend greater heights. This has necessarily not been our strength in the past.

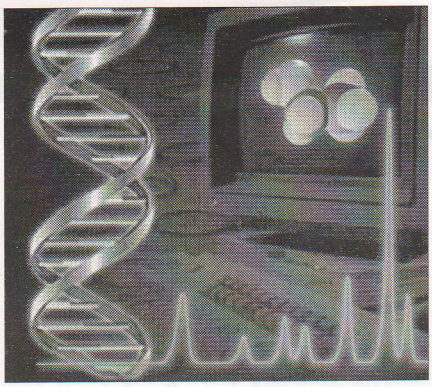
We chose two programmes to implement this concept. A biomass-based fermentation process for L-lactic acid and development of materials for fuels cells. We have created teams, which are cross-functional and share a common goal. The teams are encouraged to manage themselves.

Could you explain the current research, technology and business models being adopted by NCL to deliver quality products and services to its clients worldwide?

Our technology and industrial research is increasingly better focussed on goals and deliverables, which have to be proven in practise in the short- and medium-term. Most of these are innovation-driven and not necessarily discovery-driven.

Most of the short- and medium-term industrial research is done in collaboration with companies because we believe that if it is a short- or medium-term goal, I must understand who my customer is and work with him right from the beginning. We do not normally undertake such projects on our own.

We work with about 60 Indian and overseas companies today. Our income



from such contract research activities is about Rs. 10-crore. NCL's total income is about Rs. 15-crore - the remaining Rs. 5-crore comes from non-governmental funding agencies, based on peer reviewed and accepted proposals submitted by our scientific staff

Apart from working with industry in increasing efficiencies of existing processes, we are also looking at developing new products and processes for them. In the last few years, three of our products have gone into the marketplace: a water-soluble monomer, called ATBS, manufactured by Vinati Organics, which, I believe, is doing well after some initial teething problems; we had a successful launch for another specialty monomer that we developed some years ago called THPE. We also have a chiral drug, S-amlodipine, in the market in collaboration with Emcure Pharmaceuticals, which is doing very well.

Looking at our pipeline, we have several of our processes reaching the pilot plant stage. We have processes for 4-MAP (4-methoxyacetophenone), *p*-aminophenol (a pharma intermediate), and a clarifying agent for polyolefins.

We are also working on a process for fractionating bagasse into value added products like hemicellulose, cellulose

Directed Mission Mode programs

Biomass-based process for L-lactic acid fermentation

There is considerable interest in L-lactic acid today, as it is increasingly emerging as a platform chemical, which can be derived from renewable resources. This research programme has been funded through the 'New Millennium Indian Techno-logy Leadership Initiative (NMITLI)' of CSIR and has participation from industries, universities and CSIR, besides NCL.

Since sugarcane is an abundant agricultural resource, NCL decided to look at developing a process for L-lactic acid from sugar cane juice, at an acceptable cost and quality for this lactic acid to be converted to a wide variety of end-uses including polymers. This project brought together scientists from the biochemical sciences, biochemical engineering, chemical engineering, polymer sciences and analytical sciences group of NCL. NCL has set a stiff internal target of Rs. 75 per kg of monomer grade L-lactic acid. It has been working on this project for the last one-and-a-half years and is close to attaining the target set.

Materials for fuel cells

The other project on which NCL has been working on for the past eight months is in the fuel cells area. The focus here is on materials innovation - organic polymers, inorganic, electro catalysis and hybrids - which can lead to enhanced performance and reduced cost of fuel cells. In this effort NCL has physical chemists, electro-chemists, materials chemists, polymer chemists and chemical engineers, all working together as a team.

and lignin, under another NMITLI program. A demonstration pilot facility for this process will go on stream by end 2005.

Could you explain the rationale behind setting up the resource centre at NCL and how the industry could leverage these competitively?

When I took over, I decided that we should create a concept called 'resource centre' for multiple reasons. We wanted all the activities in the lab, which had both internal and external service focus, to have an identity, rather than being a part of a division or department. We wanted them to become a cost centre, which is budgeted separately and I also wanted to track their revenues. Although these were services done for outsiders, in our internal accounting systems these revenues were getting merged. So it was not visible to the people who were involved in this activity.

The idea was to make the system transparent so that everyone could see what was the cost being incurred and how much revenue was being generated from external sources. It is my desire that internally also we must price these services. We have not yet done this, but I would like to do it in the next couple of years.

My internal customers should also know that there is a price one has to pay for such services. Otherwise, it gets hidden in the internal cost structure. This will make my scientific colleagues more aware of what the true cost of research is. We want to drive a message in the system that this is a common resource - if it is a part of a division or a department, it doesn't appear so.

The whole idea of creating these resource centres was that it became the focus of my attention as Director in terms of resource allocation and performances. So it got the attention of the management at the highest level. We allocate budgets to them on an annual basis. Now there is a greater accountability.

Lastly, my honest opinion is that these resources are under-utilised. This is true of almost all public-funded research labs. If you look at the kind of resources laboratories have and the kind of investment they have made in sophisticated facilities, their utilisation in terms of number of hours is not very satisfactory. Most of these facilities are capable of 24 x 7 operations. We have slowly opened up many of our facilities after office hours and on Saturdays and Sundays. But we have limitations; we do not have the kind of staff needed to run these facilities on a 24-hour basis. Therefore, I am looking at how to sweat these assets more. One way to do that is to place such resources into a joint venture with a company, where, the latter manages the facility for us. The company undertakes to render services to NCL and also creates a revenue stream by deploying the balance of time available for services to customers outside of NCL. This is a future option that research labs like us should look at seriously. Treating these as independent cost and revenue centres makes evaluation of such future options easier. If you are managing it internally, you do not understand the true costs.

How do you rate NCL's competencies with those of other institutions in India?

In the area of catalysis, and polymers there is a disturbing trend in the country. The breadth and depth of research in these two areas in academic institutions appear to be on a decline, based on an analysis of publications emerging from India in quality journals. In fact, in these two areas, NCL is becoming the only sustainable group in the country, which will survive over the coming years, in terms of second and third generation scientific staff and contemporary research facilities.

I don't think this is a happy situation for the country; I would like to be number 1 amongst 20-30 groups, but to be number 1 with none else could lead to a dangerous situation of complacency.

In disciplines such as advanced ma-

Value-added products from bagasse

In a project under the New Millennium Indian Technology Leadership Initiative (NMITLI), NCL is in the process of putting up a pilot plant in a sugar factory for demonstrating a process to split bagasse into cellulose, hemi-cellulose and lignin.

Bagasse is one of the abundantly available by-products of the sugar industry, which is used only as a fuel today. NCL has developed a process to isolate all the three valuable components of bagasse in high yields.

The lignin that is isolated is of very high quality, when compared to that derived from the paper industry. This opens up many potential applications for lignin, which has a huge global market.

Dr. Sivaram says, "This process is generic, as it can be applied to any biomass. We are setting up a 50-100 kg biomass fractionating facility in a sugar factory, which will be commissioned by December this year. It will produce enough quantities of cellulose and lignin for sampling to consumer industries. Surprisingly, India imports most of its domestic requirement of cellulose/lignin."

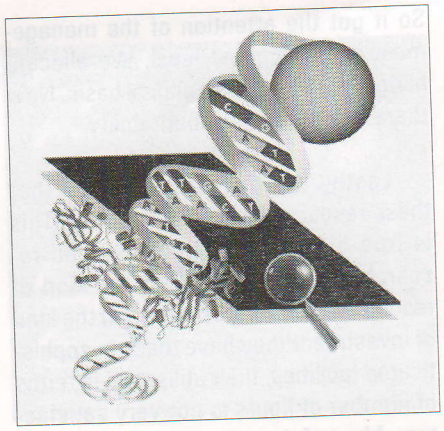
terials, including complex fluids, theory and computational chemistry, organic chemistry, process simulation, flow and mathematical modelling, NCL compares favourably with the best of the groups in India. Recognizing our contributions to nanoscience, the Department of Science and Technology has recently accorded to NCL the status of a 'Centre of Excellence' in Nanoscience.

How would you assess your business from overseas companies?

It is reasonably good. Today, our revenue stream is as follows: of our total earnings, 60% comes from industries and 40% from Government projects. Out of the 60% from industries, 25% is from global companies and 35% from Indian companies.

Three years ago, the ratio was loaded in favour of projects for the industry, with 80% coming from it. In my opinion that was not the right balance. Because, if you put 80% of your resources in contract research, you are only looking at short- and medium-term projects. This lab has an obligation to also deploy some of its resources on building long-term competencies. I cannot put all my resources on projects, which are maturing in a year or two. Then two things happen - the challenge that we will handle is much lower in terms of science and technology; and, secondly, we may loose sight of opportunities, which have value in the longer term.

During the past three years, we have undertaken course correction. Presently, we are operating at a ratio of about 60:40, which I think for a lab of NCL's size, is a reasonably healthy balance between what I call a short- & medium- term investment and long-term investment in research.



How active is NCL in the area of biotechnology?

Over a period of time, bio-related sciences at NCL has evolved into three independent broad areas. One group deals with tissue culture, the other is a group that is involved in plant biotechnology and the third is a group which is basically focussed on microbial and enzymatic process technologies and their underlying science.

Tissue culture and plant biotechnology, by its very nature, is somewhat far removed from the main body of NCL's core scientific interest. These expertises were developed at NCL about two decades ago and have sustained since then. NCL has made significant and pioneering contributions in both these areas.

We continue to nurture these competencies. However, I must admit, NCL's critical mass is rather low in these areas, compared to other laboratories in India, who have a more dominating presence, both within and outside CISR.

When we contemplate the future of these areas at NCL, I ask myself the question: "With incremental investment of resources, in which of these areas can I be counted amongst the first two or three in this country in terms of scientific excellence?" If I am not going to be among the first two or three, I ask myself whether it is worth staying in that area.

In both these areas, namely, plant biotechnology and tissue culture, we need to strongly network with other centres of excellence in India, where complementary strength exists, so that, together, we can make progress in selected areas. The areas of enzyme and microbial science are of great importance to chemical science. Fermentation technologies, microbial transformations, enzyme-assisted chemical reactions and nanobiotechnology have a great relevance to the so called 'white revolution' in chemical industry. We are attempting to create strong linkages of this group to disciplines like organic chemistry and material science. Chemical biology is another area, which is attracting our attention today. This is an interface area, which provides an understanding of how small organic molecules interact with biological macromolecules.

The area requires organic chemistry, structural biology, molecular biology and medicinal chemistry disciplines to work together. We believe that this is an area where NCL can create a future centre of excellence.

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Tell us about the infrastructure development activities taking place at NCL.

In terms of infrastructure, we built a new building – Digital Information Resource Centre, about a year-and-a-half ago. This is the first building we completed in our campus after almost twenty years. We are now about to receive approval for a new laboratory building of about 70,000 sq feet, where we wish to experiment with the concept of seamless, borderless laboratories.

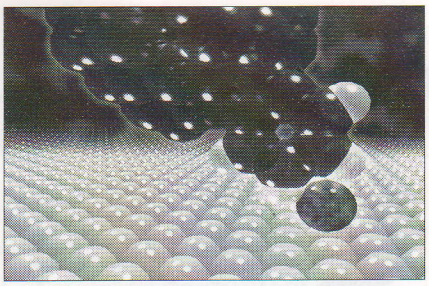
The laboratory will have a lot of interdependency built into it. They will be devoted to advanced and functional materials and will cover all aspects of material sciences, namely, organic, inorganic, polymers, bio, etc. It is an Rs.12-crore investment, with expected date of completion being early 2007.

NCL is aggressively pursuing its vision of bringing the power of IT to all aspects of management of a laboratory, as large and diverse as NCL. The idea is to improve productivity, minimize human intervention and enhance transparency in decision making. We spend on an average about Rs. 1-2 crore per annum from our internal resources in enhancing our IT capabilities.

What kind of change has taken place within the system to enable more flexibility?

There are many new CSIR initiatives in the offing that will have an impact on a lab like NCL. These will make our interface with business more simple and flexible. Each lab will have to define its own sphere of operations and customise its relationships to suit its own needs.

CSIR is building greater flexibility into its systems and procedures. Several bold initiatives to further enhance public-private partnership in research have been announced by CSIR.



Could you explain your new initiatives and, in particular, the concept of incubators?

We are at an early stage of planning to build an 'Enterprise Centre for Advanced Materials' which will function as an incubator for early state innovations. The proposed centre will be open to all innovators, both from within and outside of CSIR. We have received assurance of funding for setting up such a centre. We will dedicate, over a period of time, around 10,000-sq.feet of fully built in, plug and play, laboratory/office space for this activity.

We are also negotiating with a company in India to set up their R&D centre in the vicinity of our campus. We are examining similar opportunities with more companies. Many companies are interested in incubating their R&D for a few years near NCL, before they establish their independent research facilities. The advantage is that they can quickly start up their R&D with a minimum of capital investments since they will be able to share the vast S&T infrastructure of NCL. They will also have access to some of the best scientists (as consultants), bright students for potential employment and state-of-the-art analytical, as well as information support, facilities.

Several other public/private partnership models beyond sponsored/contract research activities are also being explored.

We are in the process of creating a 'Molecular Repository' for organic compounds. In effect, this will be a repository of molecules synthesized at NCL and stored under optimal conditions for future needs.

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Where do you see NCL five years from now?

The world of S&T is changing rapidly. Landscape of R&D is also undergoing major transformations in India. It is, therefore, of importance for NCL to ask the question as to which of the areas we are currently in would continue to be relevant 5-10 years now.

We need to address issues such as: 'Are the resources being invested in the right areas?' 'Are we chasing the right goals?'

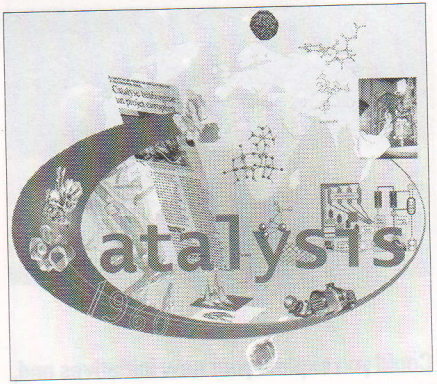
Industrial research was once the exclusive domain of CSIR laboratories. This is no longer so. We are critically assessing our competitive space in the light of emerging R&D capabilities in the private sector, of both, Indian and global companies, as well as contract research organizations.

NCL would like to clearly differentiate its competence from these emerging R&D and service organizations. NCL, by very nature of its structure, cannot and should not compete with them. We need to complement the private sector R&D by providing support in areas where they have little competence or do not wish to develop competence. We see many such opportunities in the future for NCL.

I am of the opinion that in the current state of India's development, there is certainly a place for publicly funded R&D organizations, such as, NCL.

NCL is also in the midst of an exercise to create a road map for its broad functional disciplines. The objective is to better understand our strength and weakness and define areas where we need to built new competencies and areas which we need to phase out in the years to come. We have created discipline-wide Task Forces to discuss and define the future directions. This is both a bottom-up and top-down approach.

Areas currently under discussions are related to polymer science, organic chemistry, as well as catalysis and fine chemicals. The whole purpose is to create a cohesive shared vision of where NCL should be 5-10 years now, map its evolution and



define strategies for growth in areas which are likely to be of importance in the future.

As India's S&T infrastructure, especially in the industrial sector, progressively matures, I see a changing role for NCL in the future. Some of the present models of NCL's interaction with industry will necessarily have to undergo change. NCL will be compelled to generate a larger proportion its income from knowledge-driven innovations. NCL will increasingly become part of networks of knowledge alliances, involving industry and other academic institutions, both within India and outside. The Laboratory will have to sustain its excellence in core scientific disciplines in chemical sciences.

NCL will also increasingly assume the character of a Research University, a place where fundamental science of the highest quality is practised with a clear focus on translating the good science into applications relevant to society and industry. More of our scientists will become innovators and entrepreneurs and will venture into converting their discoveries from the laboratory to wealth in society. Internally, I expect NCL to break down all barriers of traditional discipline and work more and more in the interface areas in seamless, cross-functional teams.